Clues to the relative timing of lakes in Gale Crater. W. E. Dietrich[1], M. C. Palucis[1], T. Parker[2], D. Rubin[3], K. Lewis[4], D. Sumner[5], and R.M.E Williams[6]. [1]University of California, Berkeley, CA, bill@eps.berkeley.edu and mpalucis@berkeley.edu, [2]Jet Propulsion Laboratory, Pasadena, CA, timothy.j.parker@jpl.nasa.gov, [3]U.S. Geological Survey, Santa Cruz, CA, geology.dr@gmail.com, [4]Princeton University, Princeton, New Jersey, kwlewis@princeton.edu, [5]University of California, Davis, Davis, CA, dysumner@ucdavis.edu, [6]Planetary Science Institute, Tucson, AZ, Williams@psi.edu (author list might change)

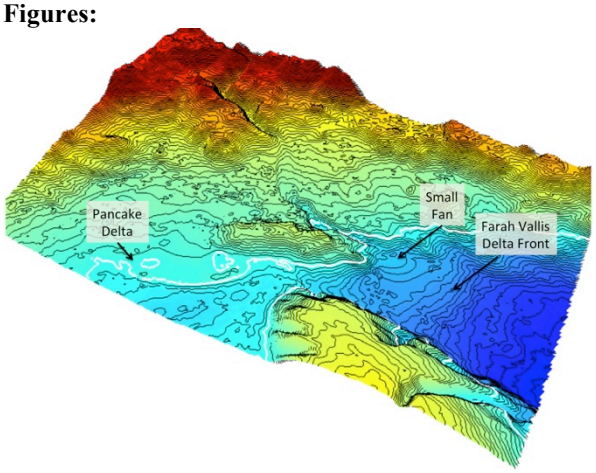
Introduction: Several groups have proposed that in Gale Crater lakes developed to various depths after Aeolis Mons (informally referred to as Mt. Sharp) had evolved to a form close to its current topography [1-6]. Here we use CTX and HiRISE imagery and topography derived from CTX, HiRISE and HRSC stereo images to document a sequence of lake levels, providing a possible relative timeline of the hydrologic events within Gale crater. This has implications for understanding regional paleo-climates on Mars, as well as providing context for the geology and sedimentology along the *Curiosity* rover traverse from Bradbury Landing to the base on Mt. Sharp.

Observations: Four inferred fan/delta deposits define the lake levels [3, 4]. Figure 1 shows an oblique view of the Farah Vallis area of Gale. A small fan has built across the lower Farah Vallis delta (about -3800m). The "pancake delta" (about -3300m) is shown in Figure 2. The western delta (about -3950 m) is shown in Figure 3. Figure 4 shows a narrow, knobby deposit of coarse sediment derived from an upslope gully (erosion and deposition volume each about 0.02 km^3) cut into Mt. Sharp. This deposit extends out of the proposed entrance canyon to Mt. Sharp and may record an upward younging sequence of debris flow fan/deltas [4]. The contour elevations of the three higher deltas are shown in Figure 4. The steep front of one of the inferred fan/deltas corresponds to the delta level at the western delta (-3950) and the apex of the highest delta form corresponds to the Farah Vallis delta. The pancake delta height is well above these features. The entire deposit in Figure 4, however, lies above the apex of the Peace Vallis fan [7].

Interpretations: The Gale impact disrupted a river valley network draining ~270,000 km^2 [2]. Since impact, a ~26 km canyon cut back across the ejecta and the sediment outflow spilled to form the pancake delta and the adjacent plains to the west. This plain was subsequently incised ~11 km as the lake level dropped and the resulting sediment produced the Farah Vallis fan/delta. If the entrance canyon deposits record a back-stepping sequence of fan/deltas [4], then a corresponding hydrologic sequence is suggested. After formation of the Farah Vallis delta, the inflow of water from the Farah Vallis canyon declined or ceased, and the lake level dropped considerably (at least below the entrance canyon deposits). At a later time, local precipitation drove gully erosion of the surrounding rim, and, perhaps amplified with renewed Farah Vallis runoff, caused a rising lake level that formed the boundary for the western delta and the entrance canyon deposits. This hydrologic system shut down sufficiently abruptly that the deltas did not cut down as the lake evaporated (or if frozen, then sublimated). The time gap between these two lake forming events, perhaps driven by different hydrologic systems (distal via Farah Vallis and local via precipitation), is not yet established. This analysis does not argue against the lakes at times freezing.

References: [1] Cabrol et al., 1999 [2] Irwin et al., 2005 [3] Dietrich W.E.. et al. (2013) *LPSC XLIV,* #1844 [4] Dietrich et al. (2014) *LPSC XLV,* #1684 [5] Le Deit et al., 2013, *JGR-Planets* [6] Anderson and Bell, 2010 [7] Palucis et al., 2014, *JGR-Planets*

Figures:



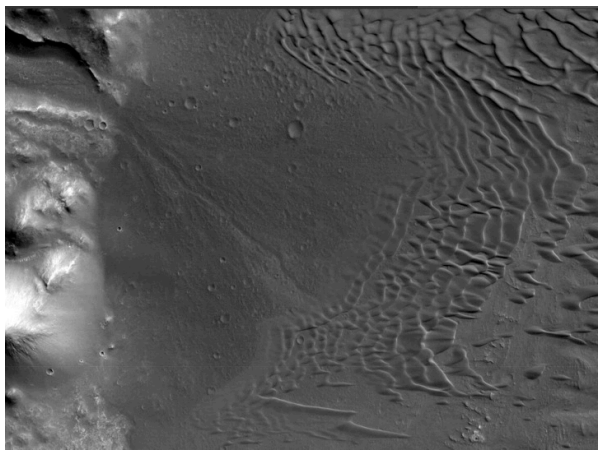


Figure 1: Oblique topographic map (colored-coded by elevation) of the southwestern corner of Gale where Farah Vallis enters and a detailed CTX image of the Farah Vallis delta system (lower portion of the map).

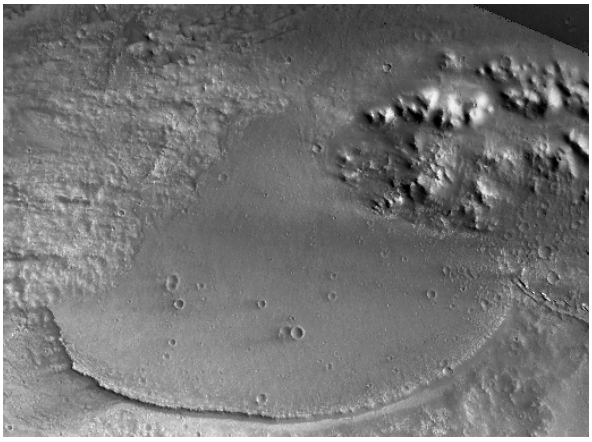


Figure 2. CTX image of the Pancake delta (see Figure 1 for its location relative to Farah Vallis).

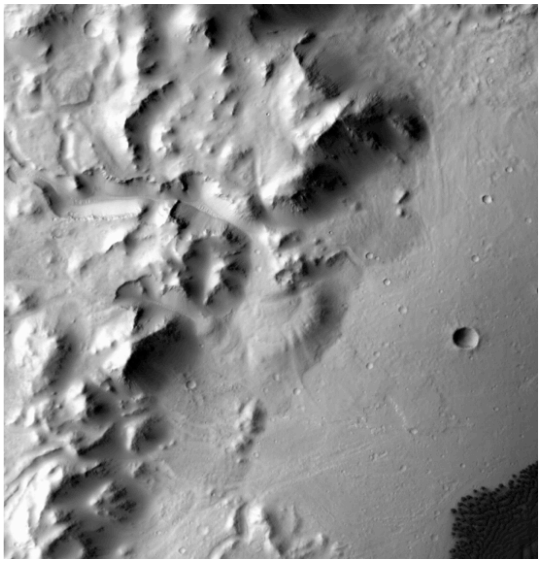


Figure 3. Fan/delta entering Gale along the northwestern rim (referred to as the "western delta").

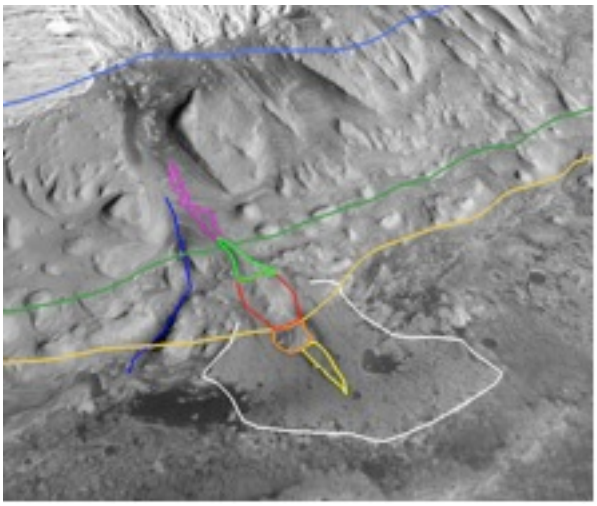


Figure 4: Geomorphic map of the lower 4 km of the Curiosity entrance canyon. The yellow and green lines correspond to possible delta heights to the west shown in Fig 1. The magenta line outlines a gully and the blue line might mark a former channel path. The green-red-orange-yellow outlines mark a succession of fan/deltas. The white line outlines a uniformly sloping surface capped by strata deposited by bedforms. The amount of material removed from the gully is approximately equal to that composing the series of fan/deltas (~0.02 km^3).

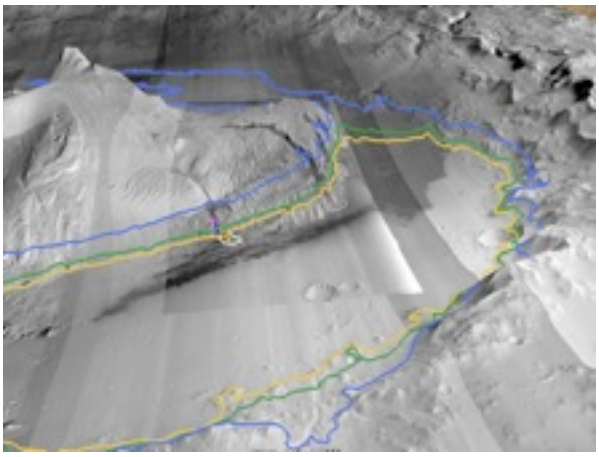


Figure 5. Three distinct fan/deltas are labeled. Yellow, green and blue lines mark the elevations that match delta forms that would be associated with paleo-lakes [3].